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## PRELIMINARY ASSESSMENT OF JUVENILE HAWAIIAN MONK SEAL SURVIVAL

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## INTRODUCTION

The northwesterly portion of the Hawaiian Archipelago beyond Kauai comprises the breeding islands of the Hawaiian monk seal, Monachus schauinslandi. The species was listed as endangered in 1976 following a 50% reduction in the number of seals counted on the beaches since counts began in the late 1950's.

Until recently, little information has been developed on survival of known age seals. Tagging of monk seals was first reported by Kenyon and Rice (1959) and Rice (1960), who tagged 59 seals, primarily pups but also older animals, at Kure Atoll, Midway Islands, and Laysan Island. The authors made no attempt to estimate survival to 1 year, presumably because their resighting effort was very limited. Wirtz (1968) tagged 149 adults or subadults and 56 pups at Kure Atoll in 1963-65. The very high mortality rate of pups during the 2-year study was striking: Of 58 pups known to have been born in 1964-65, only 3 animals are known to have survived longer than 50 days. Wirtz's study included frequent (about weekly) handling of almost all of these pups, beginning as soon as a few hours after birth, to take various measurements to follow growth and development. Twenty plus years later, these data together with the observations of others have demonstrated that monk seals are highly sensitive to human disturbance (Kenyon 1972; Schulmeister 1981). Although this research may have affected monk seal pup survival in 1964-65, mortality of immature seals at Kure Atoll was apparently high anyway during the 1960's and 1970's, based on a very low recruitment rate and declining number of births (Kenyon 1980; Johnson et al. 1982; Gilmartin and Gerrodette<sup>1</sup>). The U.S. Fish and Wildlife Service tagged monk seals of all ages opportunistically from 1966 to 1972 at most of the breeding islands, with an emphasis on pup tagging after 1968 (Johnson and Kridler 1983). As in the 1950's, inadequate resighting effort did not allow the authors to estimate survival but they did conclude that monk seals have a high fidelity to their natal beach.

In 1977, a monk seal study was initiated at Laysan Island by Johnson and Johnson (1984) to develop more life history data on the species. They bleached marked animals, including pups, for individual recognition and found that of 61 pups born in 1978 and 1979, 46 were seen early in the following field seasons, and 43 (70%) actually survived to at least 1 year of age. They reported a mean 76% annual survival in two cohorts of yearlings, and annual survival in the 2- to 4-year-olds averaged about 82%. Their data on seals over 4 years of age showed an increase in survival to about 87%. They cautioned, however, that these were minimum survival estimates because there were possibilities of seal emigration to other breeding islands and some bleached marks becoming unrecognizable between seasons.

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<sup>1</sup>Gilmartin, W. G., and T. Gerrodette. 1986. Hawaiian monk seal population status and recovery potential at Kure Atoll. Natl. Mar. Fish. Serv., NOAA, Honolulu, HI 96822-2396. Southwest Fish. Cent. Admin. Rep. H-86-16, 26 p.



In 1981, the National Marine Fisheries Service (NMFS) began an ongoing research program on the life history of the Hawaiian monk seal. Part of this research includes tagging weaned pups each year, enabling us to recognize individuals and follow their survival from year to year. This report gives preliminary estimates of survival rates during the first 4 years of life, based on data collected as part of this program through 1986.

## METHODS

The pup tagging program was initiated at Kure Atoll in 1981 (Gilmartin et al. 1986). Good survival of those tagged pups during their first summer and an apparent lack of overt problems with the tags led to a tagging evaluation study at Lisianski Island in 1982 (Henderson and Johanos in press). This study indicated there were no adverse effects of tagging pups after weaning. Tagging weaned pups was then expanded over a 2-year period and now includes all breeding islands.

Survival data in this report are from cohorts born at the major breeding areas (i.e., Kure Atoll, Pearl and Hermes Reef, Lisianski and Laysan Islands, and French Frigate Shoals) from 1981 to 1985 (Table 1). Sources of data examined in this report are listed in Table 2. Data from pups born at Necker Island were excluded because of extremely small sample size and low resight effort.

Table 1.--Pup cohorts used in calculating survival estimates. (A = postweaning survival data only; B = birth to weaning and postweaning survival data.)

| Location              | Cohort used in the analysis, by year |      |      |      |      |
|-----------------------|--------------------------------------|------|------|------|------|
|                       | 1981                                 | 1982 | 1983 | 1984 | 1985 |
| Kure Atoll            | A                                    | A    | A    | A    | A    |
| Pearl and Hermes Reef |                                      |      | A    | A    | A    |
| Lisianski Island      |                                      | B    | B    | A    | A    |
| Laysan Island         |                                      |      | B    | B    | B    |
| French Frigate Shoals |                                      |      |      | B    | B    |

## Field Methodology

Pups were tagged as soon as practicable after weaning, which was defined as the absence of the lactating female from her pup for at least 24 h. Seals were captured and restrained by hand, usually by one person but occasionally with the assistance of another individual or a net to ensure ample restraint. Another individual applied the plastic Temple

Table 2.--Sources of data examined in this report.<sup>1</sup>

| Location              | Year | Source                                       |
|-----------------------|------|----------------------------------------------|
| Kure Atoll            | 1981 | Gilmartin et al. (1986)                      |
|                       | 1982 | Bowlby and Scoggins (in prep.) <sup>2</sup>  |
|                       | 1983 | Bowlby (in prep.) <sup>3</sup>               |
|                       | 1984 | Watson et al. (in prep.) <sup>4</sup>        |
|                       | 1985 | Reddy and Griffith (in prep.) <sup>5</sup>   |
|                       | 1986 | Gilmartin (pers. commun.) <sup>6</sup>       |
| Pearl and Hermes Reef | 1983 | Morrow et al. (in prep.) <sup>7</sup>        |
|                       | 1984 | Footnote 7                                   |
|                       | 1985 | Footnote 7                                   |
|                       | 1986 | Forsyth et al. (in prep.) <sup>8</sup>       |
| Lisianski Island      | 1982 | Stone (1984); Johanos and Henderson (1986)   |
|                       | 1983 | Johanos and Kam (1986)                       |
|                       | 1984 | Alcorn et al. (in prep.) <sup>9</sup>        |
|                       | 1985 | Footnote 9                                   |
|                       | 1986 | Westlake et al. (in prep.) <sup>10</sup>     |
| Laysan Island         | 1983 | Alcorn and Buelna (in prep.) <sup>11</sup>   |
|                       | 1984 | Johanos et al. (1987)                        |
|                       | 1985 | Johanos and Austin (in prep.) <sup>12</sup>  |
|                       | 1986 | Alcorn and Westlake (in prep.) <sup>13</sup> |
| French Frigate Shoals | 1984 | Eliason (In prep.) <sup>14</sup>             |
|                       | 1985 | Eliason and Webber (in prep.) <sup>15</sup>  |
|                       | 1986 | Johanos et al. (in prep.) <sup>16</sup>      |

<sup>1</sup>The address of all data sources is the Southwest Fisheries Center Honolulu Laboratory, National Marine Fisheries Service, NOAA, 2570 Dole Street, Honolulu, HI 96822-2396.

<sup>2</sup>Bowlby, C. E., and P. D. Scoggins. In prep. Hawaiian monk seal, *Monachus schauinslandi*, at Kure Atoll, 1982.

<sup>3</sup>Bowlby, C. E. In prep. Hawaiian monk seal, *Monachus schauinslandi* at Kure Atoll, 1983.

<sup>4</sup>Watson, R. G. Peterson, and W. G. Gilmartin. In prep. Hawaiian monk seal at Kure Atoll, 1984.

<sup>5</sup>Reddy, M. L., and C. A. Griffith. In prep. Hawaiian monk seal population monitoring, pup captive maintenance program, and green turtle observations at Kure Atoll, 1985.

<sup>6</sup>Gilmartin, W. G. pers. commun., 1987.

<sup>7</sup>Morrow, R., W. G. Gilmartin, and S. Conant. In prep. The Hawaiian monk seal on Pearl and Hermes Reef, 1983, 1984, 1985.

<sup>8</sup>Forsyth, R. G., D. J. Alcorn, T. Gerrodette, and W. G. Gilmartin. In prep. The Hawaiian monk seal and green turtle on Pearl and Hermes Reef, 1986.

<sup>9</sup>Alcorn, D. J., R. G. Forsyth, and R. L. Westlake. In prep. Hawaiian monk seal and green turtle research on Lisianski Island, 1984 and 1985.

<sup>10</sup>Westlake, R. L., P. J. Siepmann, and T. Gerrodette. In prep. The Hawaiian monk seal and green turtle on Lisianski Island, 1986.

<sup>11</sup>Alcorn, D. J., and E. Buelna. In prep. The Hawaiian monk seal on Laysan Island, 1983.

<sup>12</sup>Johanos, T. C., and S. L. Austin. In prep. Hawaiian monk seal population structure, reproduction, and survival on Laysan Island, 1985.

<sup>13</sup>Alcorn, D. J., and R. L. Westlake. In prep. The Hawaiian monk seal on Laysan Island, 1986.

<sup>14</sup>Eliason, J. In prep. Hawaiian monk seal observations at French Frigate Shoals, 1984.

<sup>15</sup>Eliason, J., and M. Webber. In prep. Hawaiian monk seal observations at French Frigate Shoals, 1985.

<sup>16</sup>Johanos, T. C., J. R. Henderson, R. G. Forsyth, E. J. Walbridge, and L. D. Banish. In prep. Hawaiian monk seal research at French Frigate Shoals, 1986.



Tags,<sup>2</sup> one on each hind flipper, as described by Gilmartin et al. (1986). Tags were color coded for island of birth and drilled with a pattern of holes indicating year. The combination of tag color and number created a unique identifier for each individual.

Most weaned pups were tagged, but a few could not be tagged for various reasons, including logistics, disappearance before tagging, or because they were still nursing at the end of the field season. Information recorded at the time of tagging included tag numbers; sex, axillary girth, and length of pup; date and location of tagging; and, if known, the identity of the mother and the date of weaning.

Resightings of tagged seals within the year of tagging and in subsequent years were recorded on special data forms during beach censuses (i.e., counts of all seals on an island as described by Stone (1984)) and certain types of patrols (i.e., other observations in the census format). At one of the first few sightings of each newly tagged pup, an observer confirmed the tag numbers on right and left hind flippers and the sex of the seal. Natural markings were recorded on scar cards for each individual, and the cards were updated as the seals acquired new scars. Some pups and juveniles were also bleach marked on their pelage to enable easier identification at a distance. A sighting of an individual was recorded when enough of a tag, natural marking, or bleach mark was seen to positively identify the seal.

Both tagging and resighting efforts varied among the locations because of available program funds and the logistical difficulties related to establishing field camps at these remote sites.

### Analysis of Data

For the purpose of calculating survival rates, the following rules applied: 1) Seals were counted as alive in 1 year by a definite sighting either in that year or in a subsequent year. Definite sightings were usually made on the basis of multiple sightings within a year by more than one observer. 2) If a seal was definitely sighted and then died or disappeared during the field season, it was counted as alive for that year and as dead the following year. 3) A few prematurely weaned pups were removed from French Frigate Shoals each year as part of an ongoing special rehabilitation and research program conducted by NMFS (footnote 1). These pups were judged to have a poor chance of survival if they had remained in the wild. Prematurely weaned pups removed from French Frigate Shoals as part of this program were counted as dead the following year. This had the effect of possibly underestimating first year survival rates at French Frigate Shoals because some of these pups may have survived.

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<sup>2</sup>Reference to trade names does not imply endorsement by the National Marine Fisheries Service, NOAA.



Survival rates from birth to weaning were calculated from data collected at locations and years in which an extended field season spanned most of the pupping season and field effort was sufficient to determine the number of pups born. Postweaning survival rates were calculated primarily from tag data. However, in addition to the tag data, the first year survival rate for pups born on Lisianski Island in 1982 was calculated by combining data from tagged and bleach marked pups. Survival rates were calculated separately for each cohort per island and year (an island-year cohort) except on Kure Atoll. Data from Kure Atoll were lumped because the sample size of each cohort was less than 10. Wilcoxon's two-sample rank sum test (Snedecor and Cochran 1967) or the chi-square test was performed to determine whether differences between groups were statistically significant.

### RESULTS AND DISCUSSION

The original number of tagged pups in each island-year cohort is given in Table 3. A cumulative resighting curve for yearlings at Lisianski Island in 1983 (a 5-month field camp) indicated that on average, 95% of the surviving yearlings were sighted by the 8th alternate day count and 99% by the 10th count. Resight ability at islands other than Lisianski was not the same, however. Variables affecting resight ability included haul-out area available, topography (e.g., single island versus atoll), population size, crowding, number of observers, and research priorities. Other factors likely to affect resight ability included time of year, age of seal, and tag wear and loss over time. Considering these factors and the Lisianski Island resighting curve, resight efforts at the natal locations each year were sufficient to resight either all or most surviving tagged seals.

Table 3.--Number of weaned monk seal pups, by island and year, tagged at major Northwestern Hawaiian Islands, 1981-85.

| Location              | No. pups tagged/year |      |      |      |      |
|-----------------------|----------------------|------|------|------|------|
|                       | 1981                 | 1982 | 1983 | 1984 | 1985 |
| Kure Atoll            | 9                    | 4    | 3    | 6    | 5    |
| Pearl and Hermes Reef |                      |      | 10   | 13   | 15   |
| Lisianski Island      |                      | 13   | 24   | 15   | 14   |
| Laysan Island         |                      |      | 20   | 29   | 30   |
| French Frigate Shoals |                      |      |      | 92   | 86   |

The annual survival rates of young monk seals, based on the median percentage of tagged seals resighted at annual intervals thereafter, varied between 87 and 95% among the different islands (Fig. 1). The median annual survival of the cohorts born in various years varied from 87 to 100% (Fig. 2). The number of samples (island-year cohorts) in these groups was too few and unequal in size to conduct meaningful statistical tests, but no strong differences were apparent in survival rates among islands nor among cohorts. The overall survival rate of juveniles was 88.7% for males and 90.8% for females, and the difference was not significant (1 df,  $\chi^2 = 0.598$ ).

However, a significant difference existed in annual survival rates by age among juvenile seals. Median survival during the first year of life was lower than in subsequent years (Fig. 3). Median survival rates were 84.0% from birth to age 1 and 95.7% after age 1; the difference was significant (rank sum test,  $T = 35$ ,  $n_1 = 7$ ,  $n_2 = 9$ ,  $P < 0.01$ ). If mortality during the nursing period is excluded, survival rates from weaning to age 1 (median = 88.9%; Fig. 3) are still significantly lower than after age 1 (rank sum test,  $T = 140.5$ ,  $n_1 = 13$ ,  $n_2 = 14$ ,  $P < 0.05$ ).

A survivorship curve for juvenile monk seals also shows that the mortality rate is highest following birth and weaning (Fig. 4). Approximately 70% of seals born survive to age 4. The survivorship curve is a composite of annual survival rate estimates and, hence, is based on different sample sizes in each age interval.

These estimates of survival rates are conservative because some seals may have been missed and, hence, mistakenly counted as mortalities and no correction was applied for tag loss. As discussed previously, we attempted to minimize the first factor by devoting sufficient resighting effort at each island and by using resightings in subsequent years to correct the number surviving for a given year. As for the second factor, tag loss during this period has been very low. The loss of a single tag is uncommon, and because the seals are double-tagged, any correction in survival rate estimates to compensate for tag loss would be negligible.

During the period (1981-86) covered by this report, survival rates of juvenile seals have been high. Accordingly, at the present time and under the present conditions, there appears to be no reason to believe that survival of juvenile monk seals is an impediment to the recovery of the Hawaiian monk seal population. As these tagged seals become older, data on the survival rates of older age classes will become available.



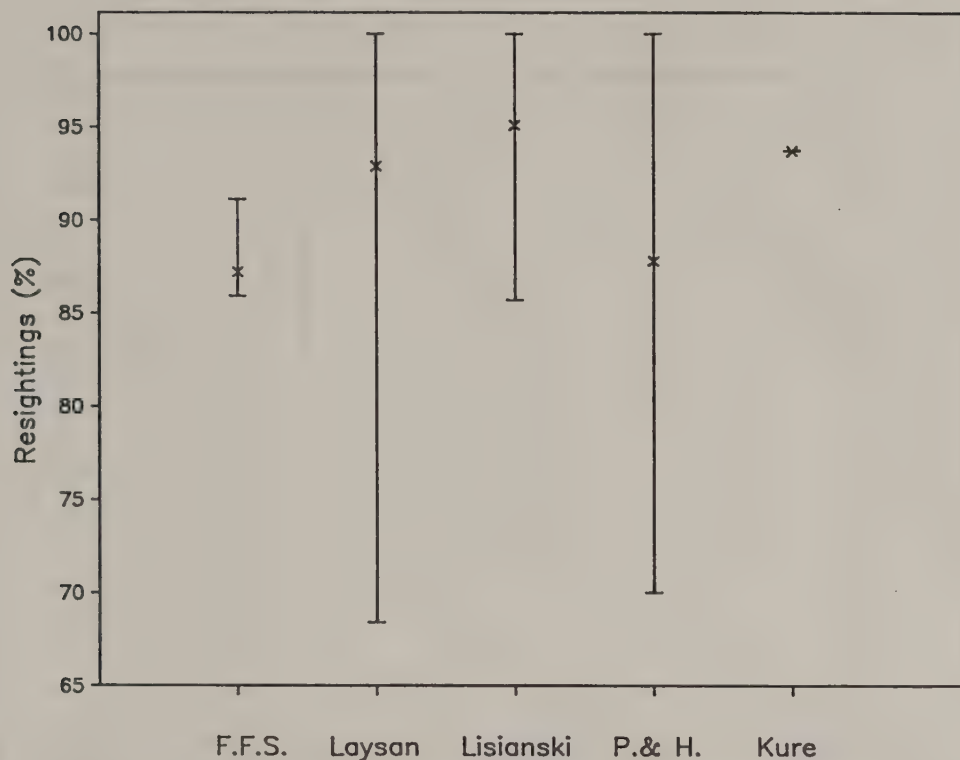


Figure 1.--Median estimates of annual survival rates of juvenile monk seals grouped by island of birth. Survival rates at Kure Atoll were pooled to give a single estimate. Lines represent the range of data points.

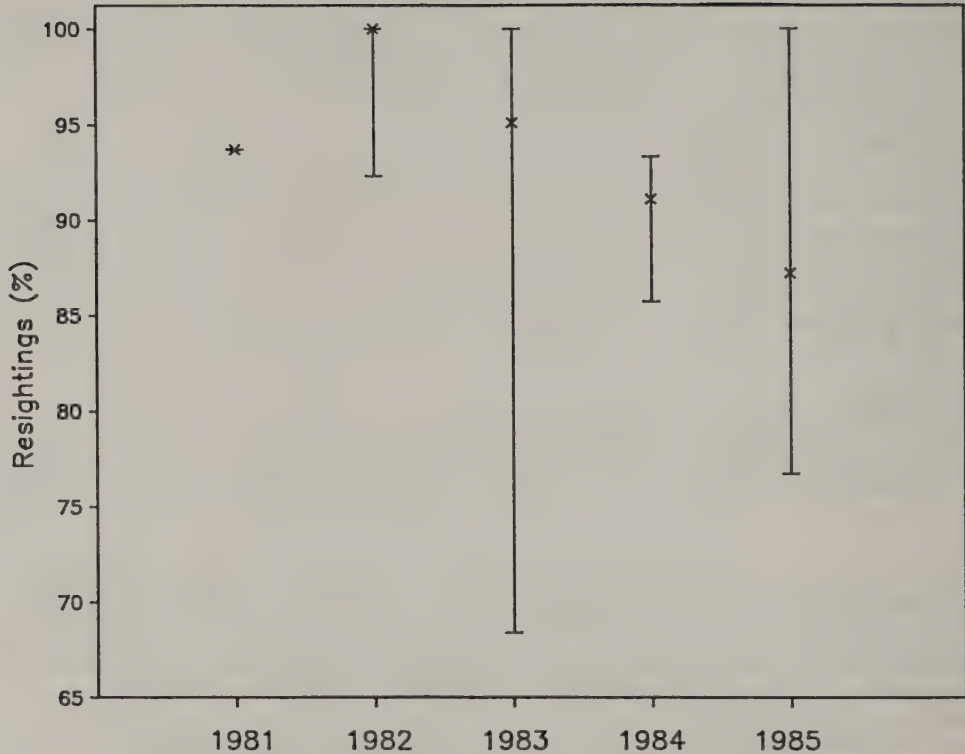


Figure 2.--Median estimates of annual survival rates of juvenile monk seals grouped by year of birth. Survival of the 1981 cohort is from Kure Atoll only and was pooled to give a single estimate. Lines represent the range of data points.



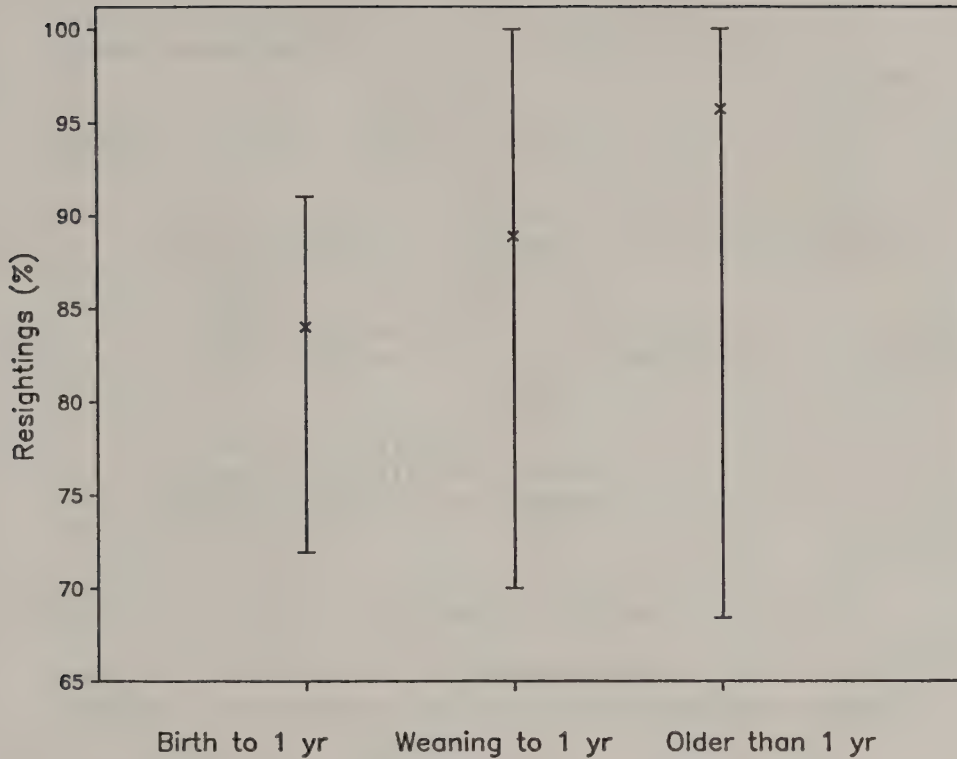


Figure 3.--Median estimates of annual survival rates of juvenile monk seals by age. Survival rates from birth to 1 year old and from weaning to 1 year old are both significantly lower than annual survival rates after 1 year of age ( $\underline{P} < 0.01$  and  $\underline{P} < 0.05$ , respectively). Lines represent the range of data points.

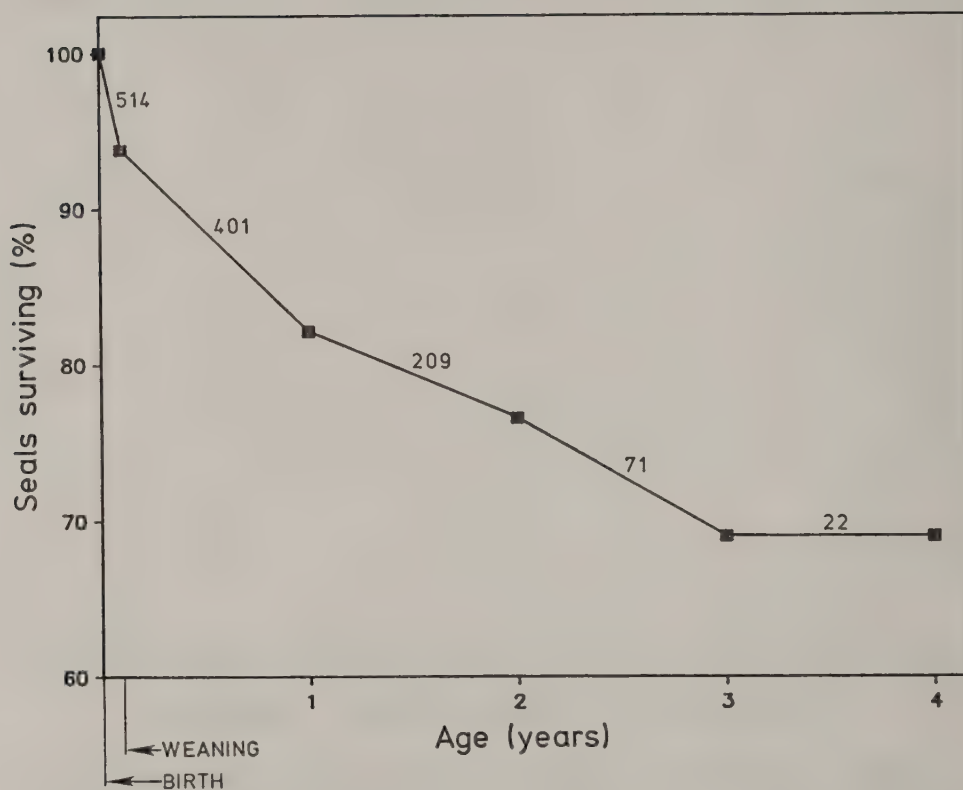


Figure 4.--Survivorship curve for juvenile monk seals. The survivorship curve is a composite of annual survival rate estimates, and, hence, is based on different sample sizes for each age interval.



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